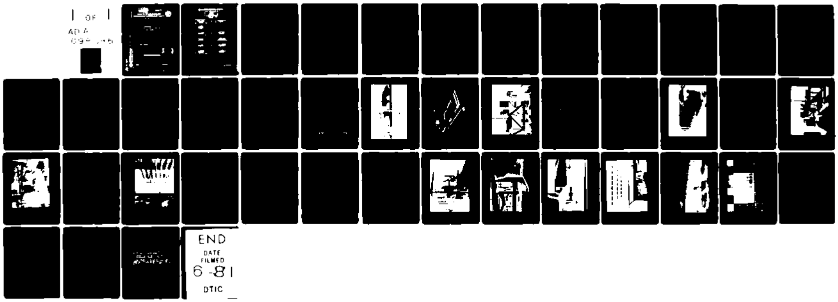
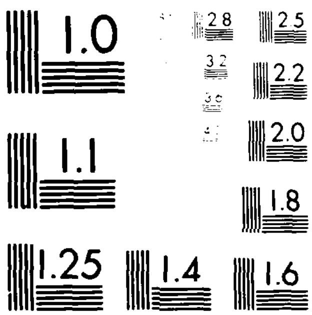
AD-A098 596 DAVID W TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CE--ETC F/G 14/2
A NEW HIGH-SPEED TOW FACILITY AT THE DAVID W. TAYLOR NAVAL SHIP--ETC(U)
APR 81 W F BROWNELL
UNCLASSIFIED DTNSRDC-81/032 NL





MICROCOPY RESOLUTION TEST CHART

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

14

1. REPORT NUMBER: DTNSRDC-81/032

2. GOVT ACCESSION NO.: AD-A098 596

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): 6 A NEW HIGH-SPEED TOW FACILITY AT THE DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

5. TYPE OF REPORT & PERIOD COVERED: 9 Final Report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): 10 W. F. Brownell

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS: David W. Taylor Naval Ship Research and Development Center, Bethesda, Maryland 20084

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Program Element 65862N, Task Area Z0833SL, Work Unit 1503-150

11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Material Command (08L21), Washington, D.C. 20360

12. REPORT DATE: 11 Apr 1981

13. NUMBER OF PAGES: 63

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 12 42

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

16 Z0833SL. F99701

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

17 Z0833SL

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Hydrodynamics
Test Equipment
Test Facility
Tow Carriage
Model Basin

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A new High-Speed Tow Facility at the David W. Taylor Naval Ship Research and Development Center is described. The information presented includes the development, construction, and use of the facility.

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

A new High-Speed Tow Facility at the David W. Taylor Naval Ship Research and Development Center is described. The information presented includes the development, construction, and the use of the facility.

ADMINISTRATIVE INFORMATION

The work performed was funded and authorized by the Naval Material Command (MAT Z08T12) under Element 65862N; Task Areas ZF09901, Z9929, ZSLD8, Z0833-SL, and Z0833SL; Work Unit 1503-150.

METRIC INFORMATION

This work performed before issuance of directives concerning use of the metric system. In the interest of the time and economy, no conversion to the metric system will be made.

INTRODUCTION

During the early 1970's, it became clear that new hydromechanics experimental facilities were urgently required to provide reliable prediction of high-speed craft and ships performance under very high speed conditions from 80 to 100 knots. The existing facilities at the David W. Taylor Naval Ship Research and Development Center (the Center) were limited by the 55-knot top speed and 0.12-g maximum acceleration of Carriage 5 in the high-speed basin.

Cavitation and ventilation are hydrodynamic phenomena which especially limit development of high-speed vehicles and ships. This applies specifically to propulsors--propeller, water-jet, pump jet; vehicle body and hull configurations; appendages such as rudders, struts, and domes. In many instances it is necessary to conduct experiments of large-scale vehicle models and components at full-scale speeds. This situation emphasizes the critical need for new facilities to solve hydrodynamic problems in the cavitation and ventilation regimes so that required performance--controllability, speed, maneuverability, and response to a seeway--and safety of high-speed craft can be realized. The planning and development for both a high-speed tow and a variable pressure flow facility were then started with the first priority being given to contructing a towing facility.

In July 1971[1*] functional specifications were completed for the High-Speed Tow Facility. Funds for the project were provided in increments over a period of several years, beginning in August 1971. A preliminary design study[2] and the final engineering plans and specifications[3] were then prepared by the AAI Corporation aided by the Ship Performance Department and Engineering Divisions of the Center. Supply-type contracts[4-12] were let for major equipment, and a construction-type contract[13] was used for the installation and site-modification work. All contracts were administered by the Chesapeake Division, Naval Facilites Engineering Command. After an extended shakedown period, the facility was placed in operation in January 1980.

GENERAL DESIGN

To carry out envisioned experimental programs, the primary requirements of the towing facility were very high carriage speed and long constant-speed runs for taking data. In addition, a relatively large basin cross sectional area and wavemaking capability were necessary. The existing facilites at the Center did not meet the speed need. A higher maximum speed than the 55 knots of Carriage 5 was required, and an early determination was made that the existing high-speed basin could be used as part of the High-Speed Tow Facility. Figure 1 shows a plan of the basin. The basin, which is filled with fresh water, is rectangular in cross section (Figure 2); it is 2968 ft long, 21 ft wide, and 10 ft deep for 1168 ft of its length and 16 ft deep for the remaining 1800 ft. The basin walls are of concrete and support two precision rails on which existing Carriages 3 and 5 run. A wavemaker was available at the east end of the basin for seaworthiness experiments. The existing Wall 4 trolley system, running the length of the basin, was a source for furnishing power to required auxiliary power supplies, located onboard the new carriage. The necessary free-water surface, long basin, large cross section, and wavemaking capability were therefore at hand. The new facility requirements then came down to providing a remotely controlled, high-speed carriage (Figure 3) having a 100-knot-speed capability and high acceleration and deceleration so that desired constant speed runs could be obtained. A steady-state run of approximately 1260 ft or 7.5 sec at 100 knots was the target. This run length was determined after allowing space for Carriages 3, 5, and 6, 1 g acceleration, braking distance, and the wavemaker.

*A complete listing of references is given on page 57.

Several propulsion systems were considered for driving the carriage, including

On-Board Conventional Drives

Water-Jet Catapults

Stored Energy Drive

Cable Drive

Vacuum Tunnel

Steam-Powered Catapult

Linear Induction Motor

The linear-induction motor drive was selected as being the most feasible for this application. Its advantages were producing thrust without physical contact; speed of motor not limited by centrifugal forces; relatively lightweight moving part of the motor, which led to high acceleration and deceleration capabilities; no wearing parts such as the gears and bearings used in conventional carriage drives.

Originally two pairs of linear induction motors were contemplated to propel the carriage. However, the high cost of two power conditioners for powering the two sets of motors called for a reexamination of the need for two pairs of motors. It was determined that one pair of linear motors could meet foreseeable requirements. Elimination of one set of motors resulted in significant reduction of carriage weight. This in combination with a model drag of 12,000 lb at 100 knots resulted in a constant speed of approximately 4 sec, which was considered acceptable.

For safety considerations, three separate braking systems were provided, namely, regenerative, friction and an emergency system. In summation, the primary additions to the high-speed basin were an equipped carriage, propulsion system, power distribution system, communications and data transmission system, various auxiliary systems, and a minicomputer.

CARRIAGE 6

The carriage (Figure 4) is a low-profile, open truss frame with an equipment room enclosure. The carriage frame consists of four 36-in.-deep rectangular box beams made up of welded aluminum tubular trusses with continuous aluminum plates bolted to the upper and lower chords. The tubes are 3 in. in diameter and have varying wall thicknesses. The forward box beam has five trusses, and the rear beam consists of three. All trusses are set at approximately 4-ft centers. The longitudinal box beams consists of three trusses. Intercostal framing is provided at truss panel points to form a space frame. Structural redundancy is provided in the design

of the three-dimensional structure and the multiple trusses which provide numerous load paths. The carriage--including all equipment, test fixtures, and models--weighs about 61,000 lb. It is designed structurally for the following model loads applied 3 ft below the water surface.

	Pounds
Drag	22,000
Lift	30,000
Side Force	15,000

The carriage is 30 ft wide, 67 ft 8 in long, and 3 ft deep, except for the 8-ft-high equipment room. A 10- by 31-ft open bay area is available aft of the equipment room for model installations. This bay is similar to the one on Carriage 5 so that existing equipment and test fixtures can be used interchangeably on either carriage.

The carriage is supported by eight 62 1/2-in.-diam, steel-tired aluminum wheels (Figure 4) which ride on the existing high-speed basin rails. It is restrained laterally by two pairs of guide wheels (Figure 5) located at the front and rear of the carriage. The 27 1/2-in.-diam, steel-tired aluminum guide wheels are located on one side of the carriage to allow for variations in rail spacing.

The 25-deg symmetrical wedge fairing at the front of the carriage is of aluminum construction and is approximately 8 ft high and 22 ft wide. Nine different configurations were investigated to find one that best satisfied the requirements of minimum drag, carriage weight, lift, water distubance, and carriage length. Friction-type breaking of the carriage is provided by eight brake assemblies with four mounted on each side of the carriage. The system is of the fail-safe type, and the brake units are spring applied with hydraulic control. Each brake assembly contains four pairs of opposing brake heads (Figure 6) for clamping brake liners to the track rails while the carriage is being stopped. One pair of brake assemblies is used independently to provide as much as 1/4 g braking for low-speed carriage operations. When all brake assemblies are used, braking to as much as 1 g is attainable.

As an added safety measure, four steel "holddowns" (Figure 7) are provided, two on each side of the carriage. These fit around the railheads with slight clearances

to avoid contact in running the carriage. The holddowns are designed to take large lifting loads in case of unanticipated model loadings. They also can handle large sideloads if one of the guide wheels fails. Further backup for excessive sideloading is provided by two pairs of rollers, which are mounted on one side of the carriage and roll along the sides of the rail.

CARRIAGE DRIVE SYSTEM

The primary operation of the carriage is in a west-to-east direction. Return runs are limited to a maximum speed of 11 fps for safety reasons. The carriage is driven by two parallel-mounted--linear-induction motors, developed by the Airesearch Manufacturing Division of Garrett Corporation. Figure 8 shows one of the motors; each has a maximum thrust capability of 20,000 lb. The two-sided motors are suspended over and react upon aluminum reaction rails which run the length of the basin. The motors are 9 ft long and weigh about 3550 lb. Their pertinent characteristics are:

Voltage	3000 V rms, 113 Hz, 3 phase
Current	1560 A per phase
Horsepower	5530
Poles	9
Air Gap	1.125 in. (nom)
Cooling Air	Ambient Air

The reaction rail is an aluminum extrusion 24.25 in. high and 0.625 in. wide; see Figure 9. The rail was delivered in 50-ft lengths and was welded at the site to form 2500-ft-long strips along each side of the basin. New concrete foundations for the reaction rails were joined to the existing basin walls. Figure 10 shows the reaction-rail installation.

A high-powered, adjustable frequency, power conditioner developed by Westinghouse Electric Corporation converts 69-kV, 60-Hz power to the variable-voltage--variable-frequency power needed to operate the linear induction motors. The upper half of Figure 11 shows the power conditioner equipment in the generator room in Building 4S. The conditioner operates in the four modes of acceleration and deceleration in forward and reverse directions of the carriage. Figure 12 shows the system. The system consists of an a-c and d-c, 12-phase, double

converter, output filter and a 24-stage, forced, commutated inverter. The power conditioner provides 16.1 MVA and 11.3 MW at the maximum frequency of 113 Hz. The operating range of the conditioner with precise control is from 2 to 113 Hz, which covers carriage speeds from 2 to 100 knots. The maximum voltage is 3000 V (rms line-line) and maximum current is 3100 A (rms). Power is supplied to the linear motors via overhead conductors and collectors mounted on top of the carriage; see Figures 1 and 13. The collectors are wired through junction boxes and are connected to the linear motors. The busbars shown in Figures 1 and 13 are 21-in.-high aluminum trusses. The busbars and collectors were developed by the H.K. Porter Company.

The power conditioner supplies accurate output in response to input command signals so that control accuracy of 0.1 percent of speed is obtained in the range from 10 to 100 knots. Frequency control signals are analog d-c voltage ranging from -10 to +10 V. Voltage boost-control signals are analog d-c voltage, ranging from 0 to +10 V.

A speed control servo loop (Figure 14) provides control signals to the power conditioner, which in turn supplies power to the linear motors. Speed and acceleration commands are entered at either the shore or the carriage console. Commands are processed by digital logic and are converted to an analog signal in a digital-to-analog converter. The analog signal, when integrated with rate feedback, controls the power conditioner. An analog tachometer mounted on a carriage wheel feeds back voltage to the power conditioner. A digtial position encoder, mounted on a wheel provides the position of the carriage and a digitial velocity signal for display and control purposes.

A data link transmits continuous command and status information between shore and carriage consoles. Figure 15 is a functional diagram of the data link.

Regenerative braking of the linear motors is the normal method of stopping the carriage. In this mode, the power conditioner converts the variable-voltage--variable-frequency power to 60 Hz and feeds it back to the power company via the substation. A secondary friction braking system is available as a backup and has been discussed herein.

Numerous interlocks are provided to protect personnel and equipment. The interlocks cover two general categories, "run inhibit" which prevents startup and "stops" which stop runs. Run inhibits are caused by electrical, electronic, and mechanical equipment not being in the proper operational mode. Stop interlocks function when there are carriage overspeed conditions at various positions in the basin, insufficient carriage deceleration, lost data link, and malfunctions in the digital speed loop.

The carriage has operated at 70 knots and, also, 0.61 g acceleration. Higher speed runs will be made as required by the experiment.

DATA TRANSMISSION SYSTEM

An optical data transmission system developed jointly by Cosmos Engineering, Inc., and ITT, Gillfillan, is used to transfer communications and data between the moving carriage and the shore-based control room. Figure 16 shows the system, which consist of three transmission links. The voice and data multiplex use links 1 and 2. The wideband video channel between the carriage and fixed terminal uses link 3.

The carriage transceiver is mounted on top of the carriage, and a fixed transceiver is mounted on a raised platform at the east end of the basin. Voice and data multiplex terminal equipment is mounted in single, enclosed cabinets at each terminal.

On link 1 command and control signals are carried from the shore control room to the carriage. This is done basically via a 50-kb/s pulse code modulation (PCM) signal. Ten independent channels of frequency shift keying (FSK) signals carry other command and control signals at a 100-Hz data rate. Figure 17 is the optical data, link-modulation plan for the overall system.

Link 2 is similar to link 1, except that return information is being carried to close the command and control loop. In addition, four more subcarriers are carried on link 2, centered on 300 kHz and 2, 3, and 11 MHz. On the 300-kHz subcarrier an analog speed feedback signal is carried, and on the 2- and 3-MHz subcarriers are forward and reverse digital tachometer signals. An 11-MHz-wideband, voltage-controlled oscillator is used to carry 2-Mb/s-PCM experimental data to shore.

Wideband, 120-MHz, 1-V video information is carried on link 3 from the carriage to the shore. A laser is used on link 3 for the optical signal source, and light-emitting diodes (LED's) are used on the other two links.

Table 1 gives the data transmission requirements.

TABLE 1 - DATA TRANSMISSION REQUIREMENTS

Control to Carriage Band Group	Function	Signal Specification	Signal Amplitude
1	Operator audio	0.2 to 3 kHz	0 dB/m
	Interlocks	10 each FSK, 100-kHz, data rate	0 and 5 V
	Emergency stop	1	
	Trackside switches	5	
	Data loss	1	
	Miscellaneous and spare	3	
2	Command and control	200-kHz, PCM	0 and 5 V
Carriage to Control			
1	Operator audio	0.2 to 3 kHz	0 dB/m
	Interlocks	10 each FSK, 100-kHz data	0 and 5 kV
2	Command and control	200-kHz PCM, 50 kb/s	0 and 5 V
3	Data from experiment	4,000-kHz PCM, 2 Mb/s	0 and 5 V
4	Speed feedback, digital fwd.	50-kHz max pulse rate	0 and 5 V
	Speed feedback, digital rev.	50-kHz max pulse rate	0 and 5 V
5	Speed feedback analog	1 Analog channel, 0 to 20 kHz	-10 to +10 V
6	Television	12.0 MHz bandwidth	1.4 V peak to peak

NOTE: PCM is pulse code modulation; FSK is frequency shift keying; kb/s is kilobits per second; Mb/s is megabits per second; dB/m is decibels per 1 milliwatt.

AUXILIARY SYSTEMS

An emergency brake system developed by the Advanced Development and Engineering Center, Gulf and Western, is available should the regenerative and friction braking not stop the carriage in the allowable distance.

The emergency brake system is of the rotary friction absorber type. One absorber is installed on each side of the basin at the east end. Figure 18 shows the emergency brake equipment.

Special nylon tapes, 12 in. wide and 0.43 in. thick, are used as the purchase or drive member. These tapes are wound on the storage reel of each unit and are run through a sheave to a tape connector assembly mounted on the sheave assembly. The sheave is located about 400 ft west of the absorber reel. A brake arm on each side of the carriage (Figure 19) engages the tape connector assembly (Figure 20). The cylinder at the left side of Figure 20 is an impact absorber to take up the initial shock loads when the arm hits the tape head. The engagement pulls out the tape and thereby turns the tape storage reels. The reel drives a hydraulic pump having an output pressure that is controlled and programed. The force developed is applied to two multiple disk aircraft brakes mounted on the reel. The resulting brake torque slows and stops the carriage within 250 ft. The energy absorbing capacity of the system is 46 by 10^6 ft-lb, and the maximum hook load is 235,000 lb.

Several power supplies furnish power to operate model motors and instrumentation on the carriage. The supplies are located on the carriage and operate from utility power transmitted via the existing Wall 4 power busbars. Figure 21 shows the busbars and collectors mounted on top of the carriage equipment room. The power supplies include:

2	50-kW, d-c, Voltage-Regulated Supplies
1	9-kW, d-c, Current-Regulated Supply
2	20-kVA, a-c, Variable-Voltage--Variable-Frequency Supplies
1	5-kVA, a-c, 400-Hz Regulator
1	15-kVA, a-c, 60-Hz Line-Voltage Regulator

An auxiliary drive system is provided to both move out and return the carriage to the fitting room area and for inching control of the carriage. This system consists of a hydraulic drive which is connected to one of the carriage wheels by a chain drive arrangement. Carriage speeds to approximately 5 knots are attained. A hand-held pendent station is used to operate the drive.

A computer system for processing and analyzing as much as 1.2 Mb/s of data is located in the shore control room.

OUTDOOR SUBSTATION

Power for carriage operation, auxiliary equipment, and instrumentation is obtained from a new 69-kV substation, located adjacent to Substation 2 at the east end of the station. The substation is shown in Figure 22. It includes two 3250-kVA, oil-immersed, outdoor-type transformers; one converts the incoming 69,000 V to 1080/624 V, the other converts 69,000 to 1080 V. In addition, a 7,500-kVA, 69,000- to 13,800/7970-V transformer is provided as a backup for the station 13.8-kV, power distributor system. A 750-kVA transformer steps down 13,800 to 480/277 V for various auxiliary services. A 225-kVA transformer steps down 480 to 208/120 V. Outdoor switchgear (Figure 23) and power distribution systems are provided as required for the various operational functions.

CONCLUSIONS

The High-Speed Tow Facility provides a significant increase to the experimental capability of the Center. Fundamental, applied, and experimental research and development programs can now be readily carried out in high-speed areas, in which research tools in the form of experimental facilities have been lacking. As a result, the operating capabilities of the fleet will be significantly improved by the ability to furnish additional hydrodynamic data needed for design purposes.

ACKNOWLEDGMENTS

The facility described in this report exists because of the efforts of many members of the staff of the Center; the Naval Material Command; Chesapeake Division, Naval Facilities Engineering Command; numerous contractors. Acknowledgment is given to the Commanders, Technical Director, and Heads of the Ship Performance Department of the Center, who furnished strong support and encouragement

through the conception, development, and construction phases of the facility. Acknowledgment is also given to the members of AAI Corporation, who were responsible for preparing engineering drawings and specifications for the project. These include F.J. Schroeder, R.L. Jarvis, E.A. Laufer, and L.E. Schaeffer.

In addition, thanks are given to P.M. Douglass, Jr., G.E. Grant, and N.B. Rothenberg of the Central Instrumentation Department for their contributions and to H.D. Harper, Ship Performance Department, for his assistance during the shakedown period of the facility.

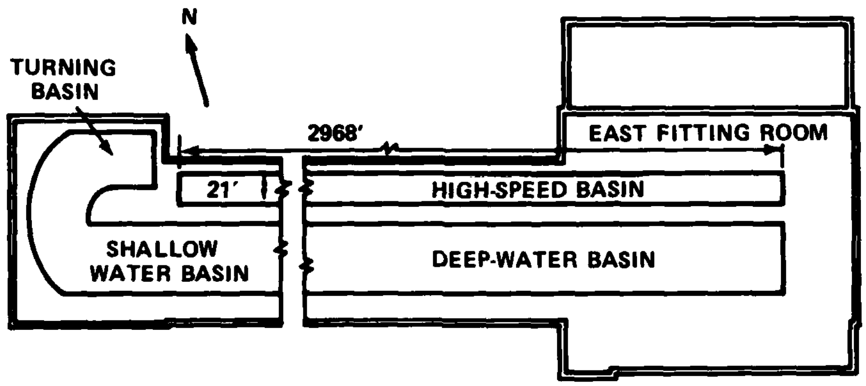


Figure 1 - Outline Plan of High-Speed Basin

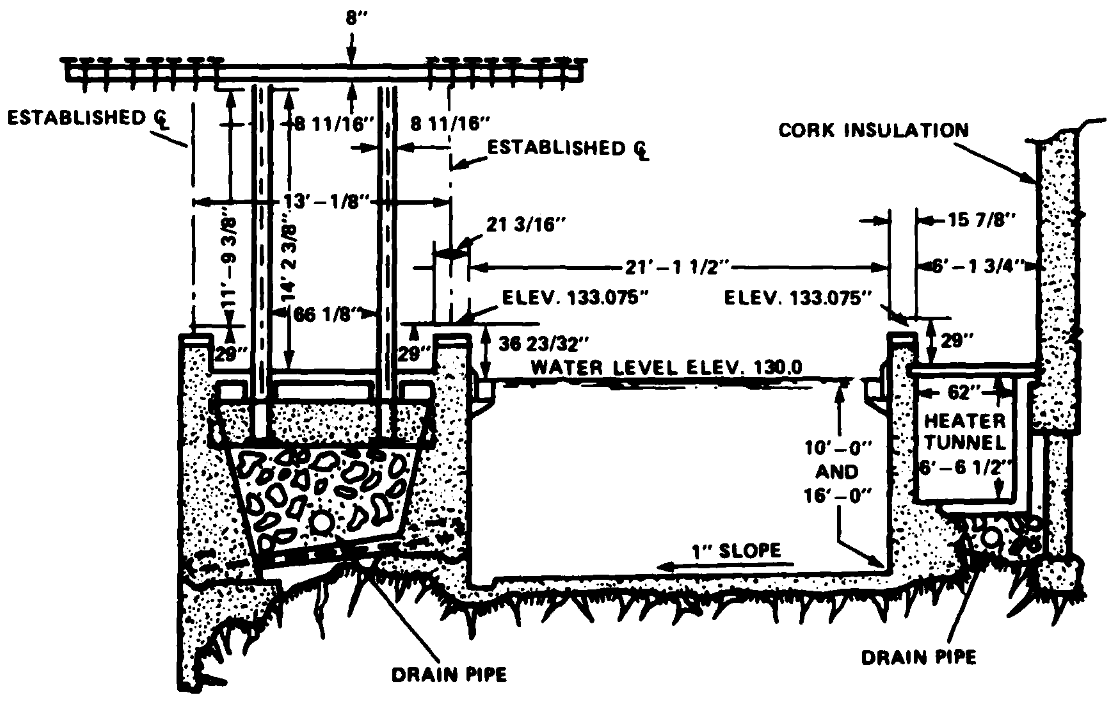


Figure 2 - Cross Sectional View of High-Speed Basin

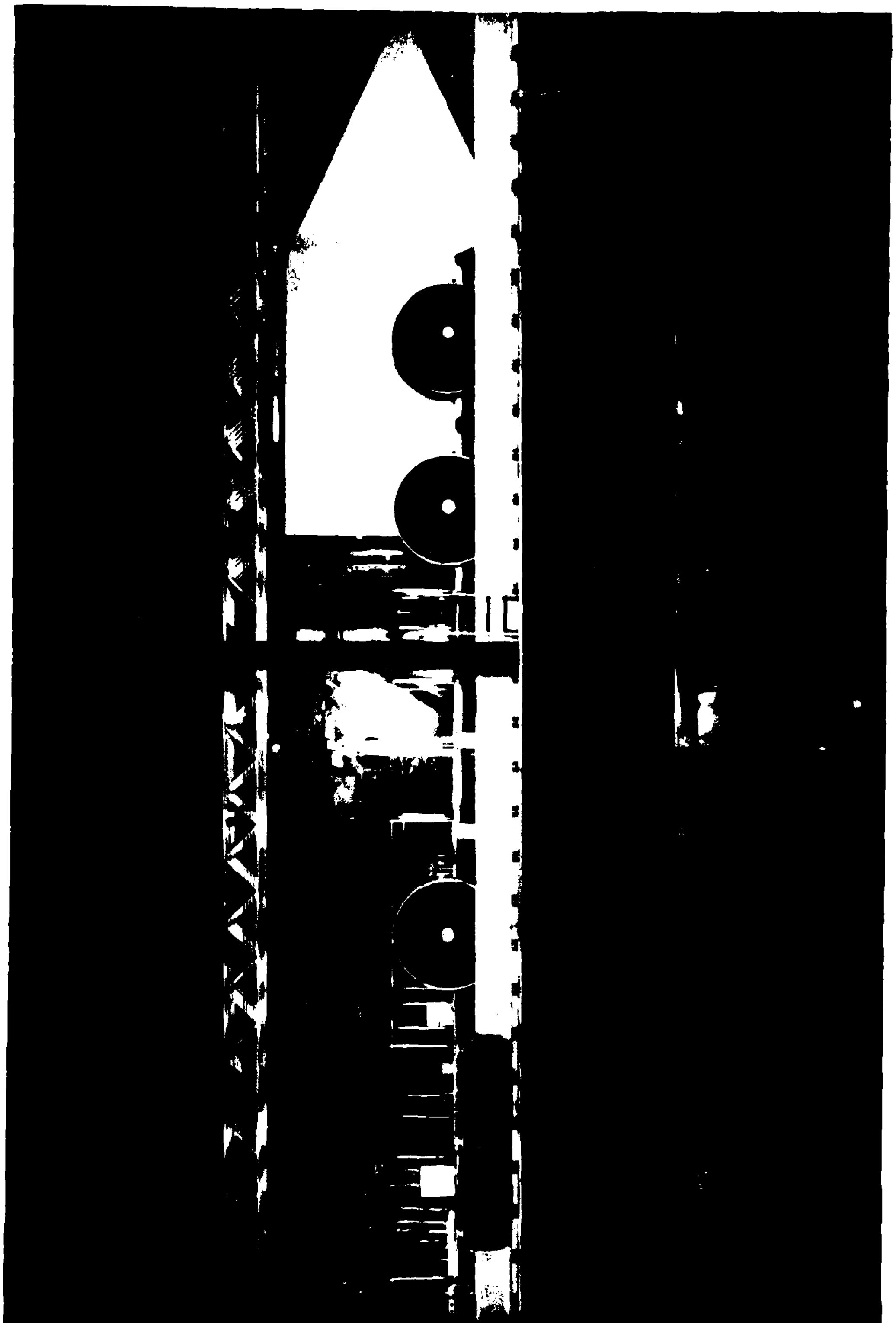


Figure 3 - Carriage 6

PRECEDING PAGE BLANK-NOT FILMED

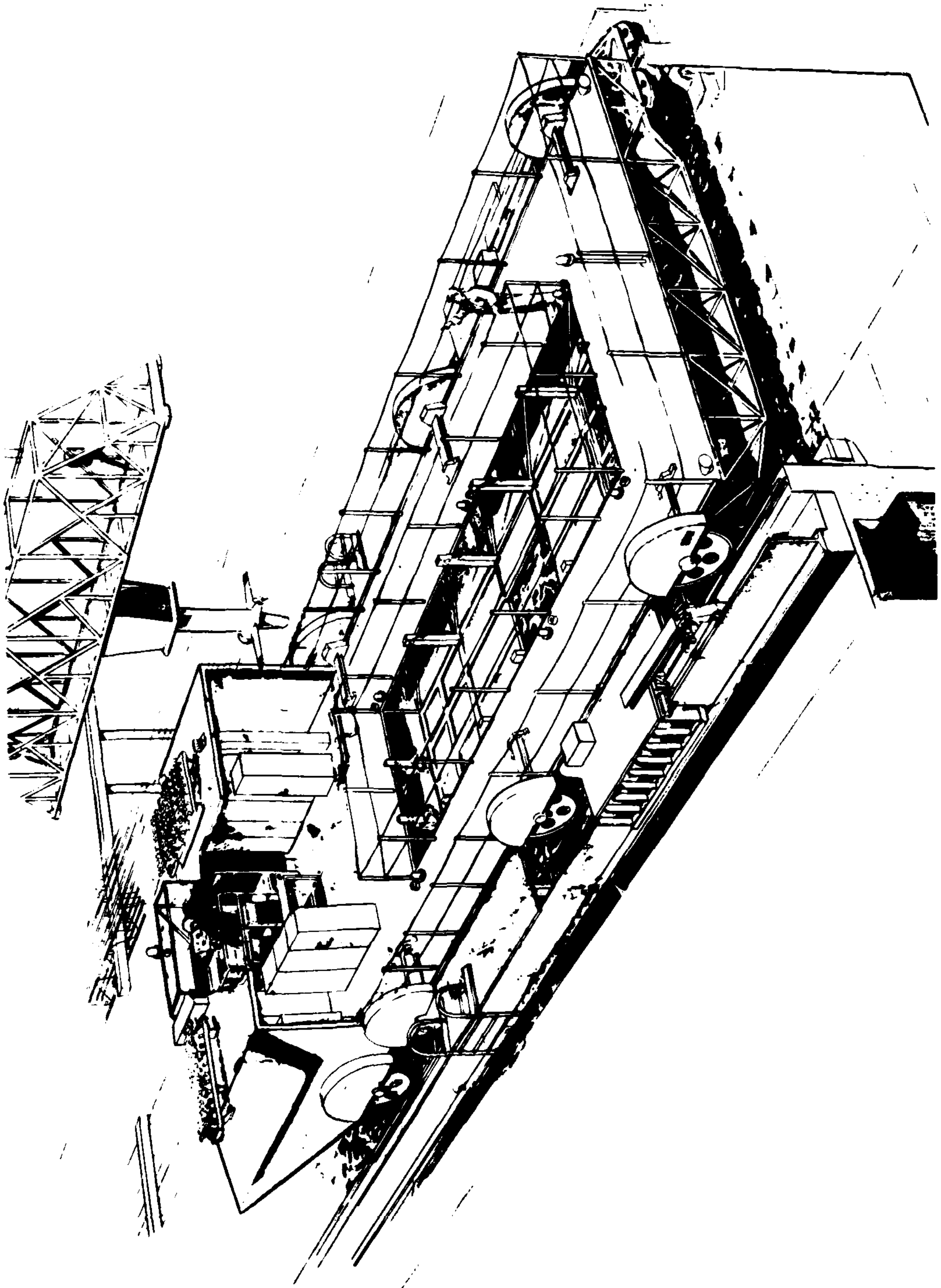


Figure 4 - Carriage 6, Showing Open Bay

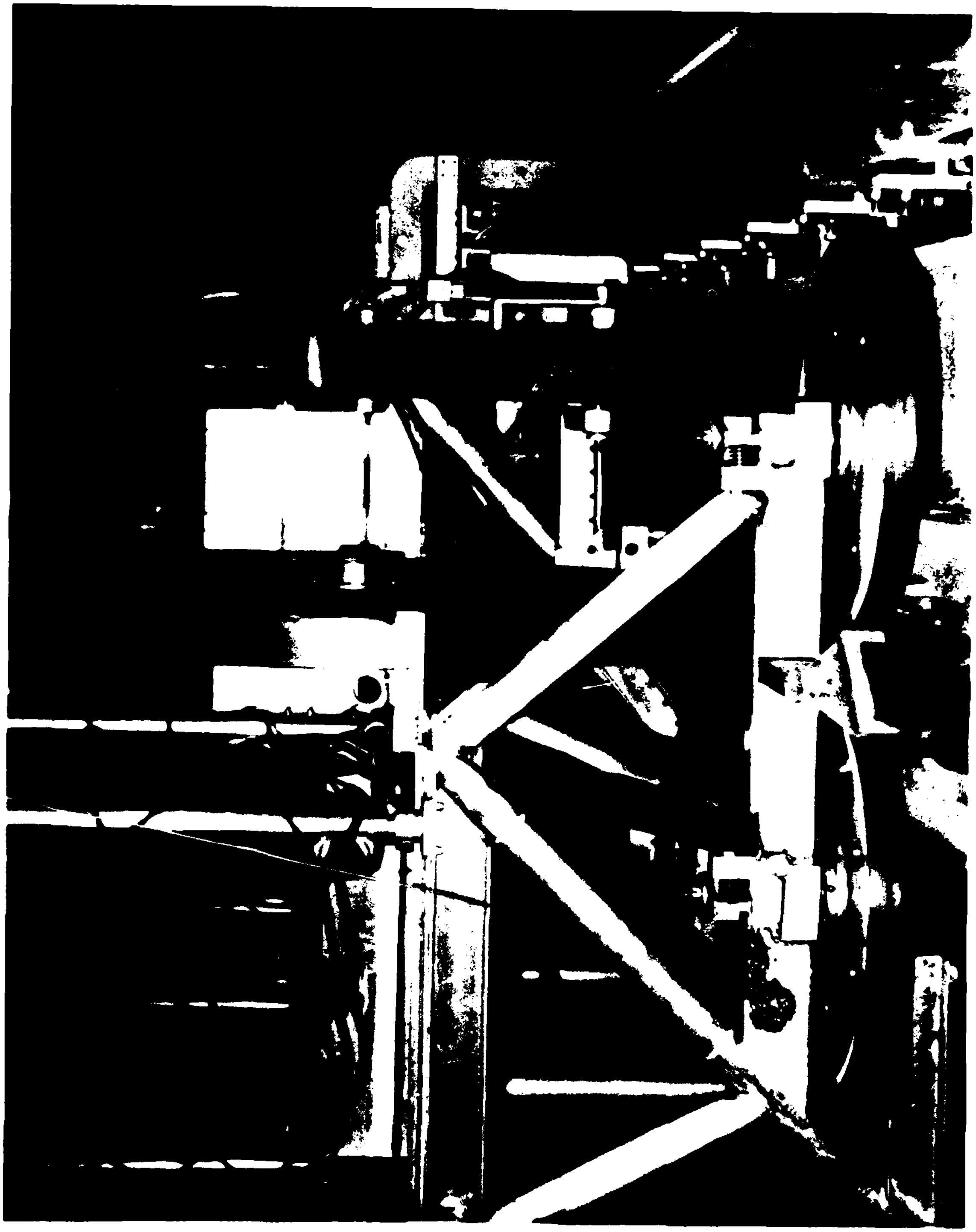


Figure 5 - Carriage 6 Guide Wheels

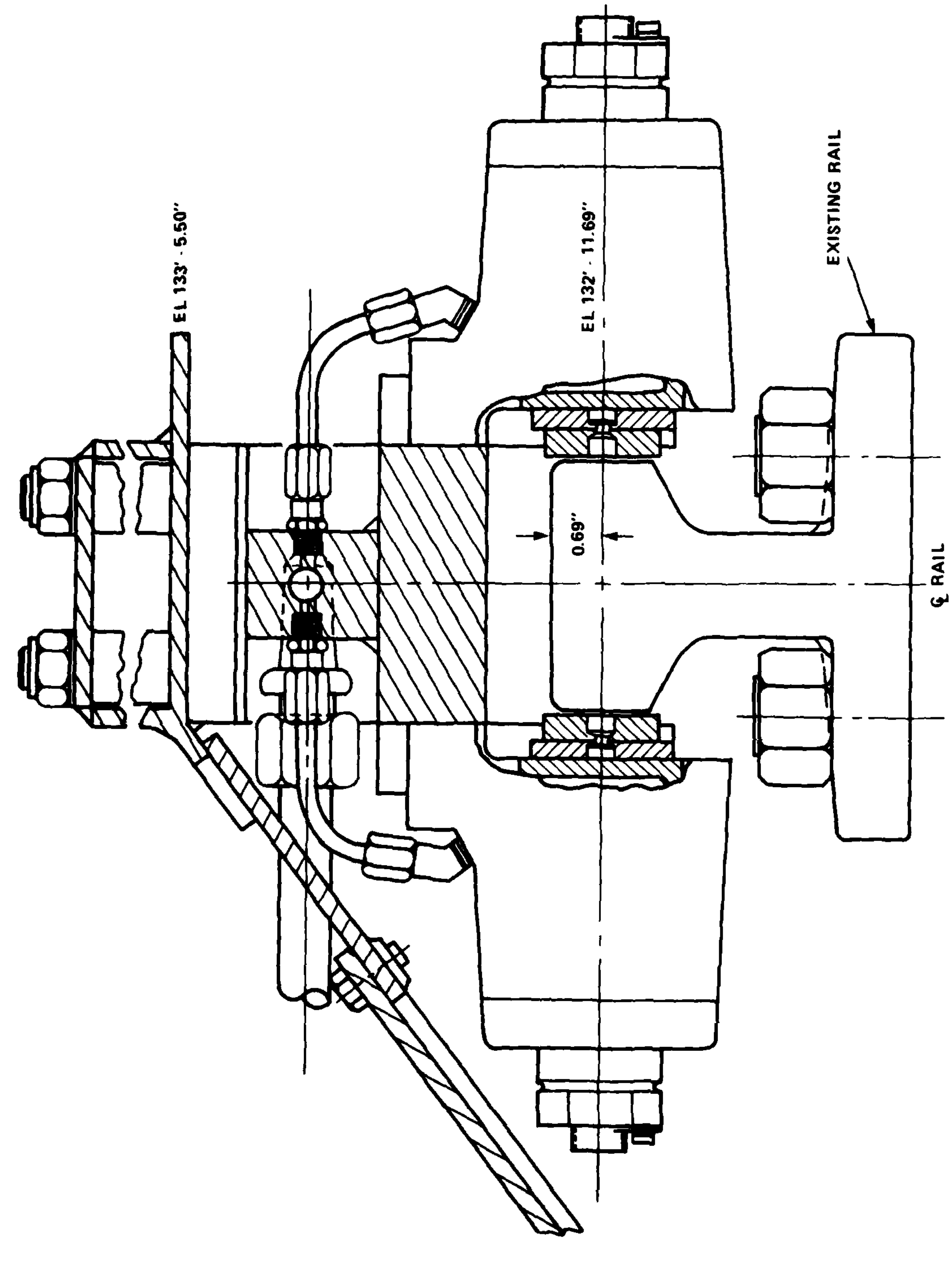


Figure 6 - One Pair of Friction Brake Heads

PRECEDING PAGE BLANK-NOT FILMED

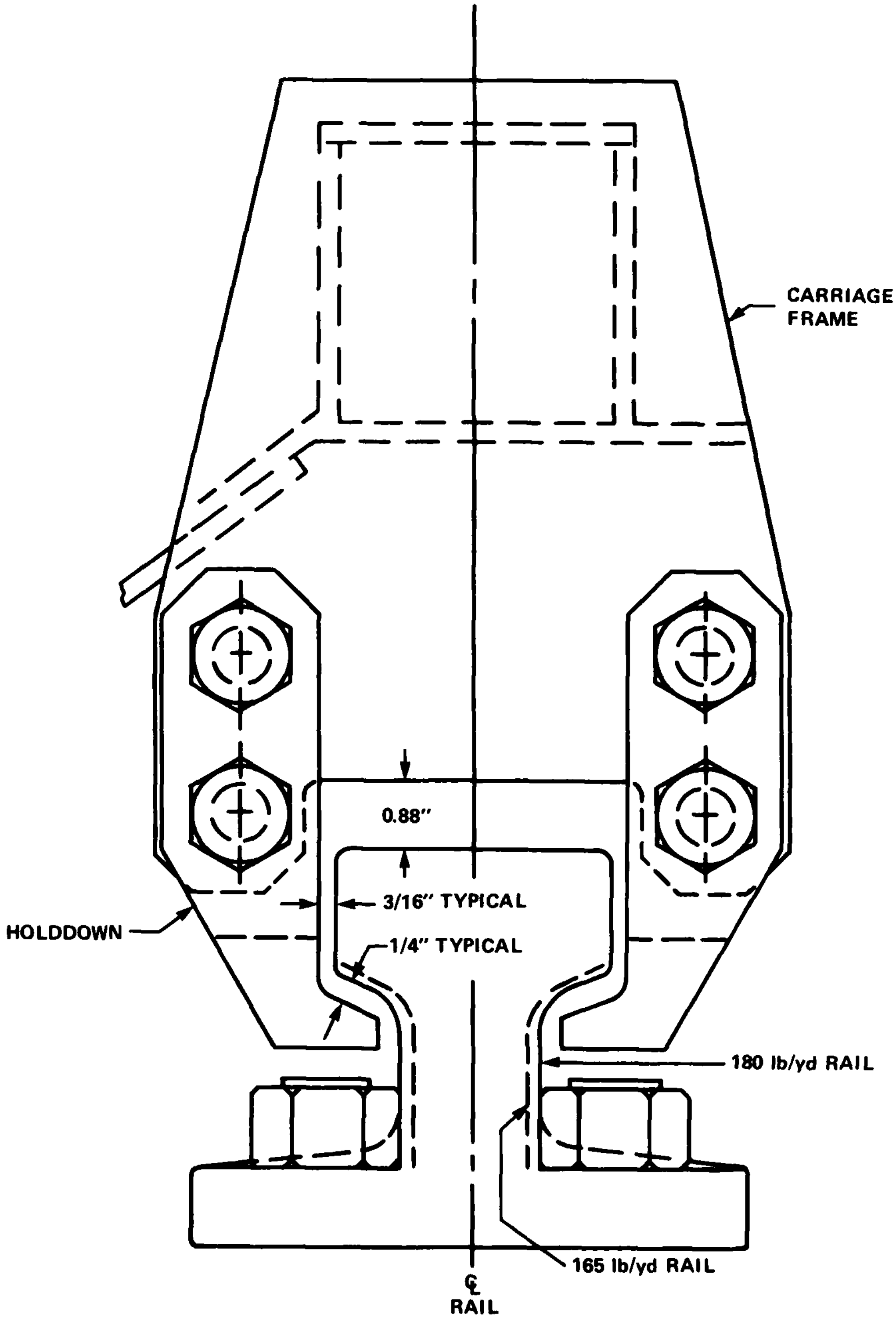


Figure 7 - Carriage Holddown

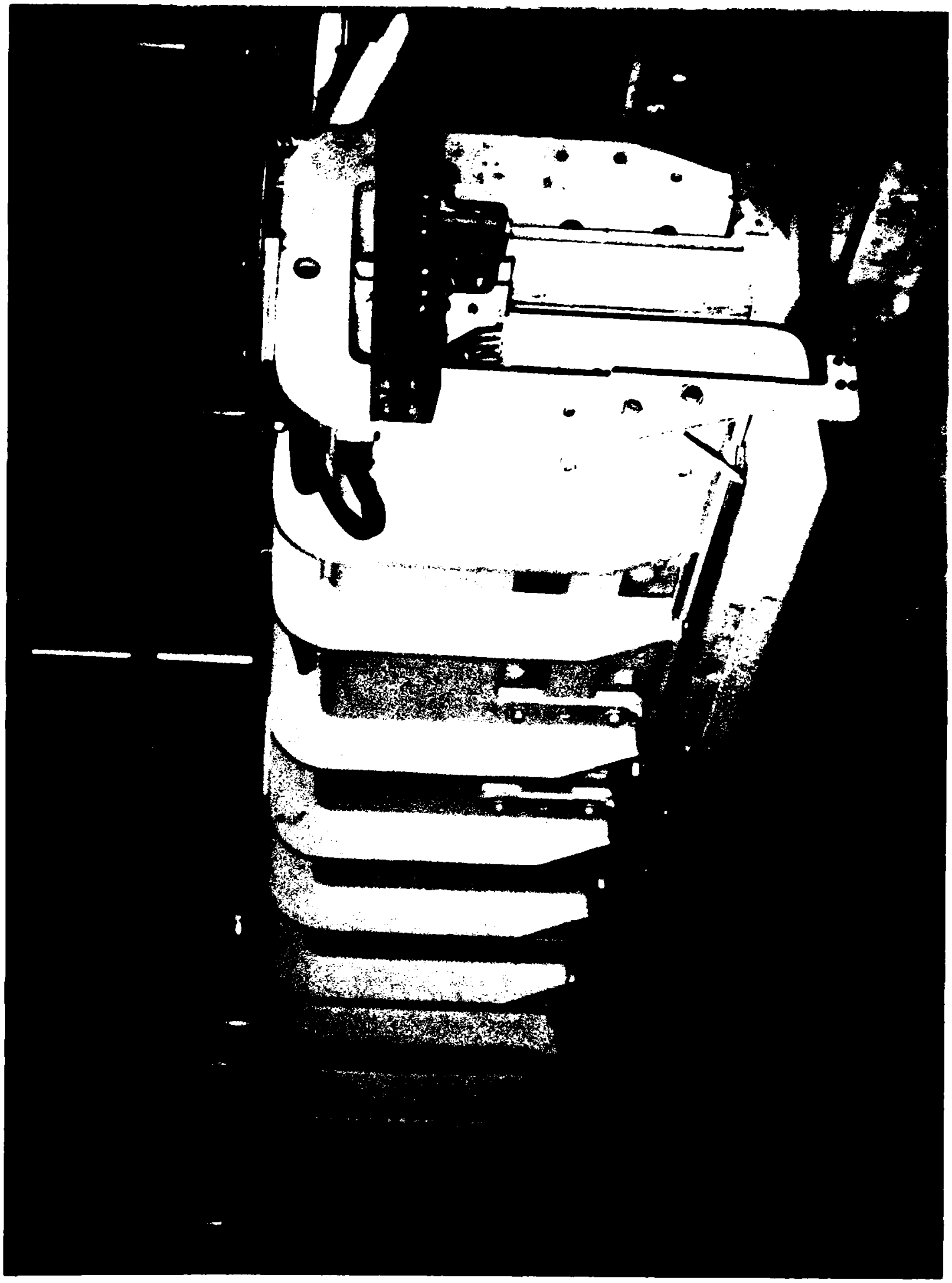


Figure 8 - Linear Induction Motor

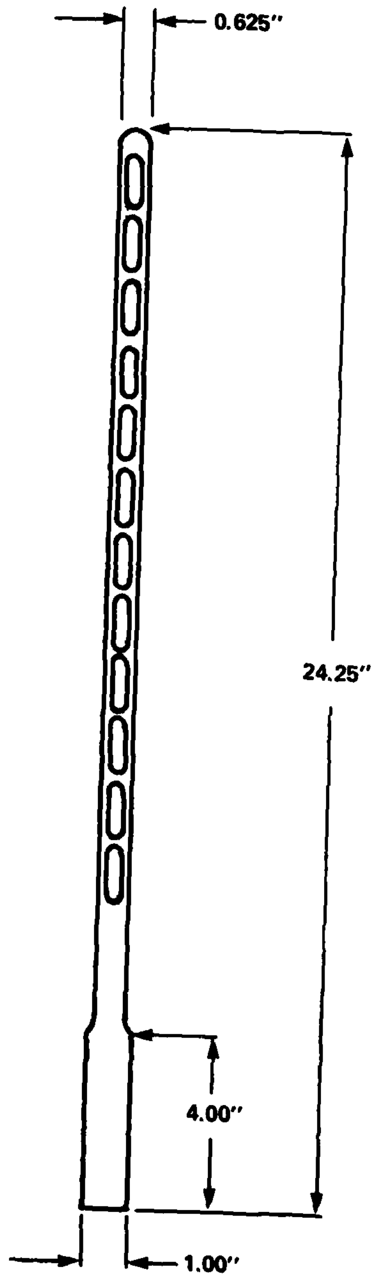


Figure 9 - Cross Section of Reaction Rail

PRECEDING PAGE BLANK-NOT FILMED

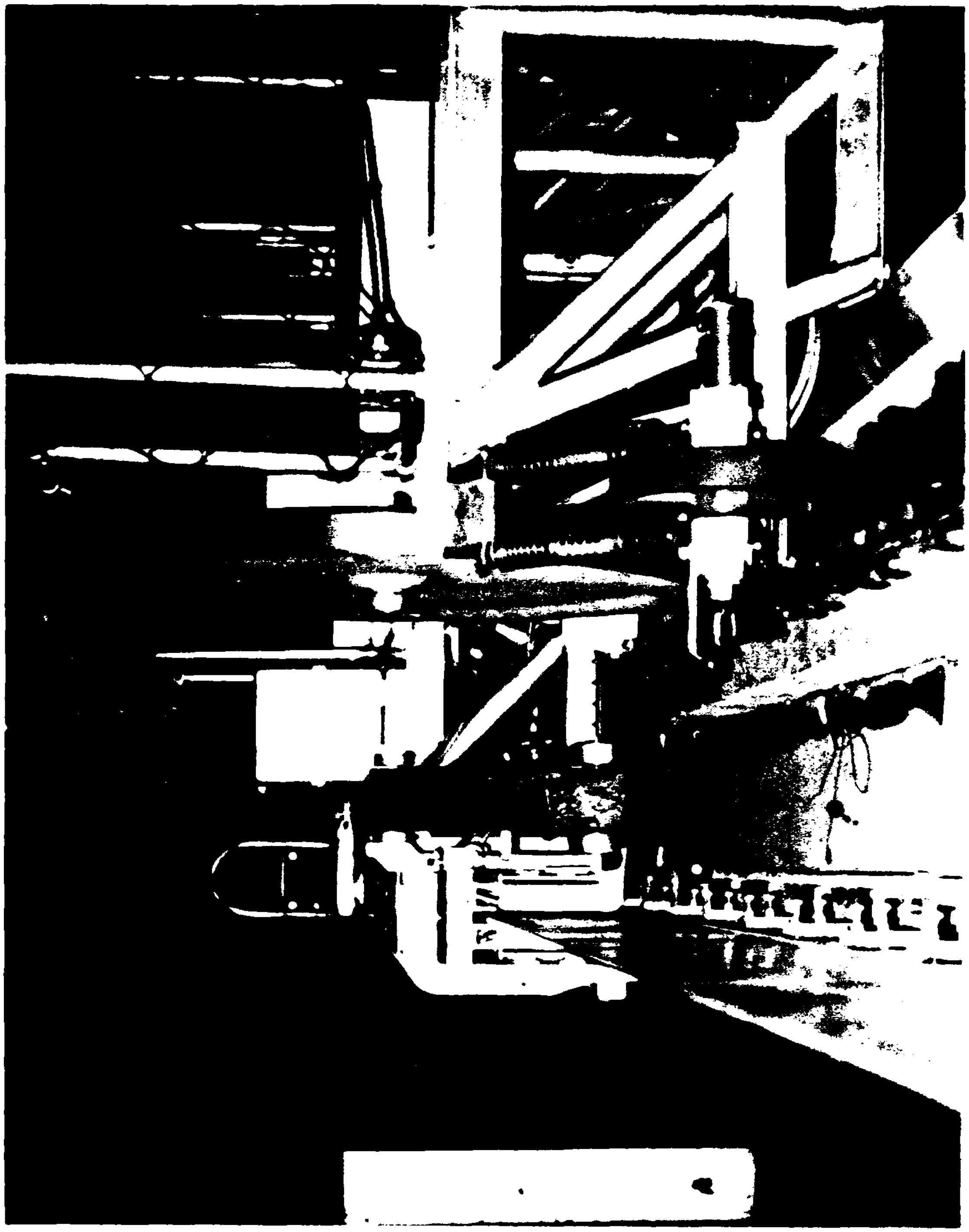


Figure 10 - Reaction-Rail Installation

Figure 11 - Power Conditioner Equipment

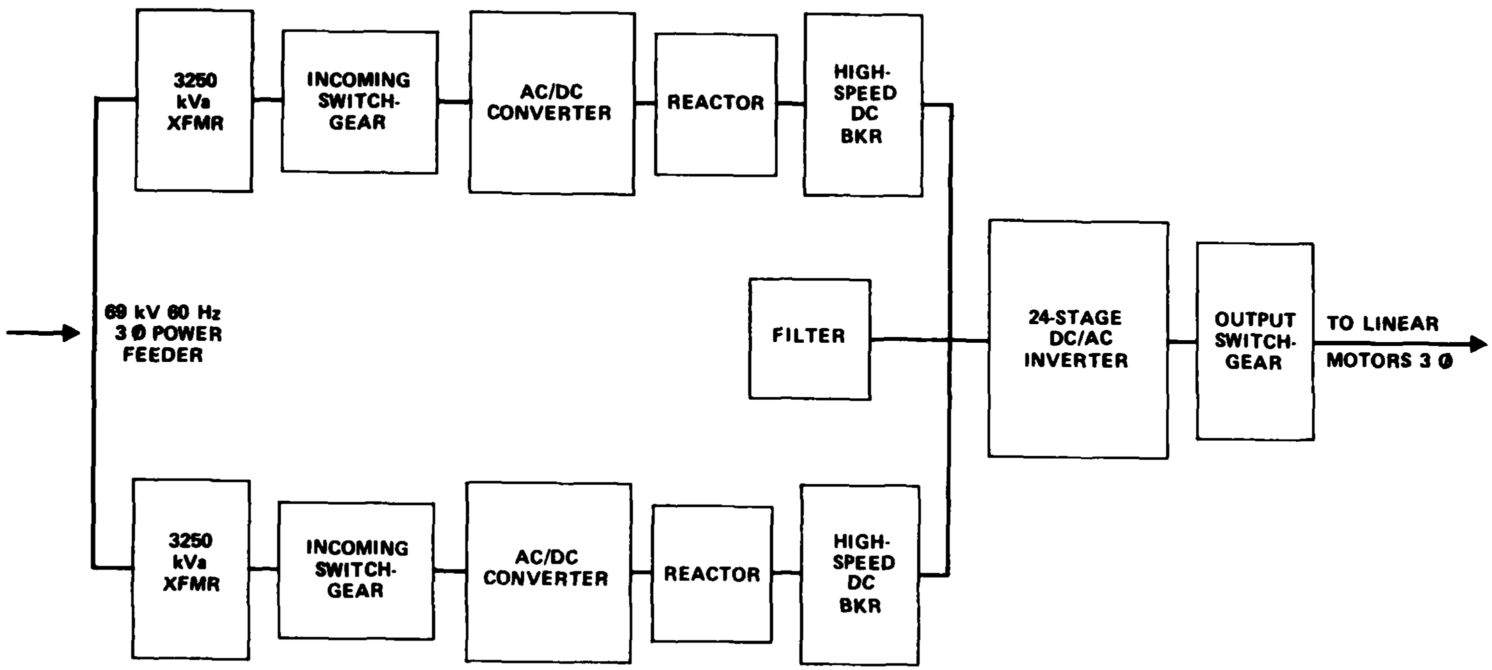


Figure 12 - Block Diagram of Power Conditioner System

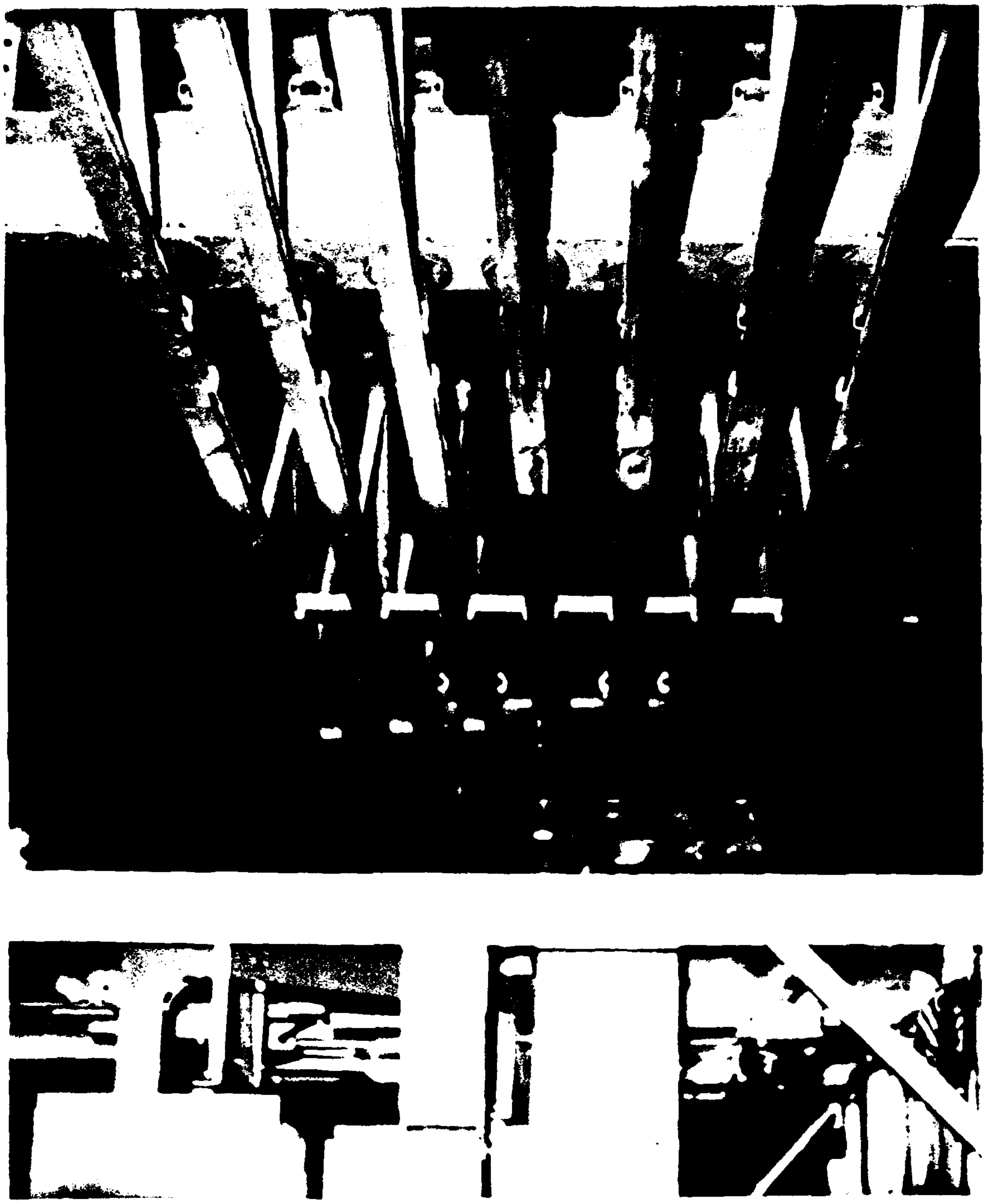


Figure 13 - Aluminum Power Busbars and Collectors
above Carriage Equipment Room

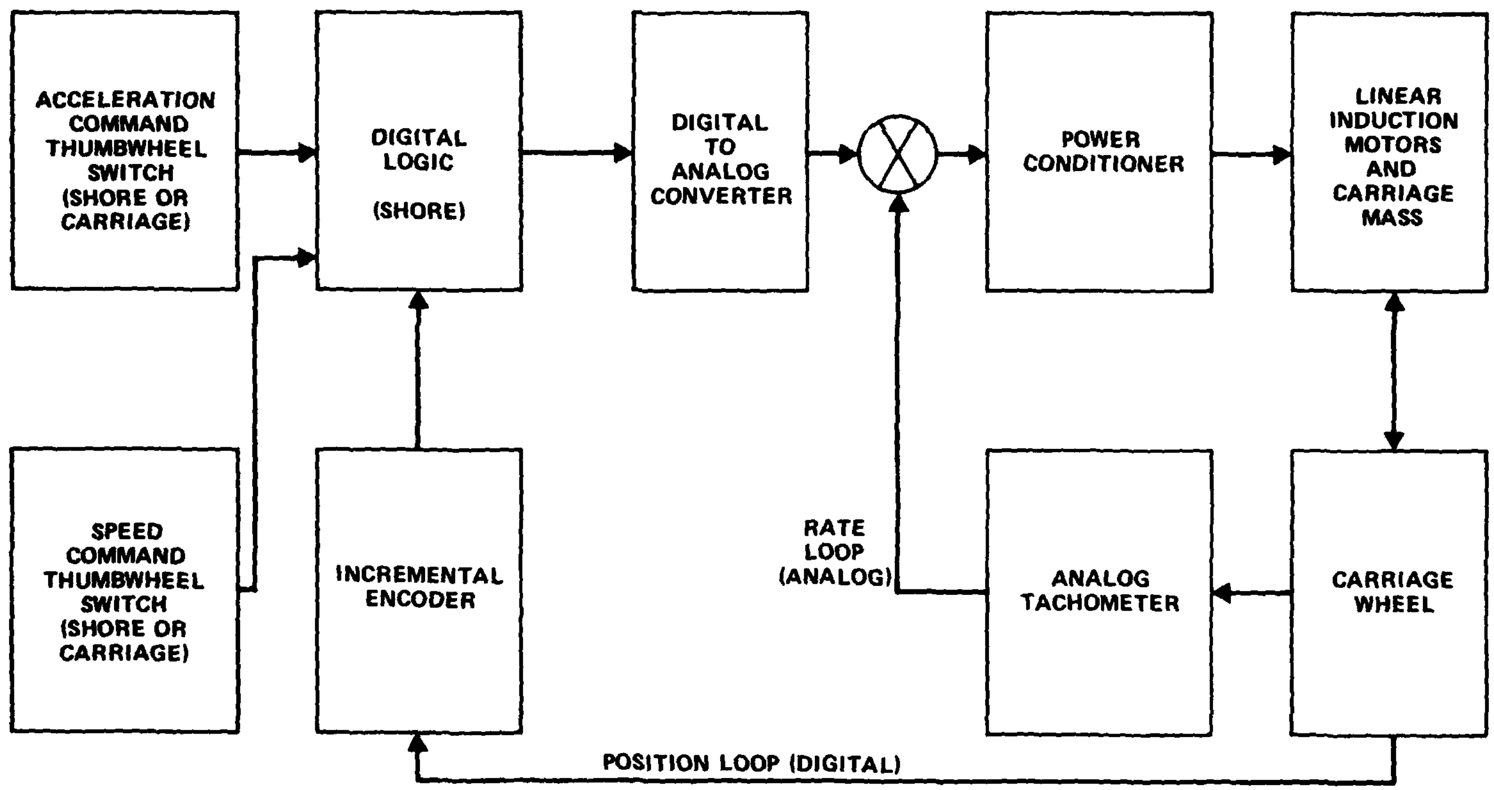


Figure 14 - Functional Diagram of Speed Control Servo Loop
(See Reference 14.)

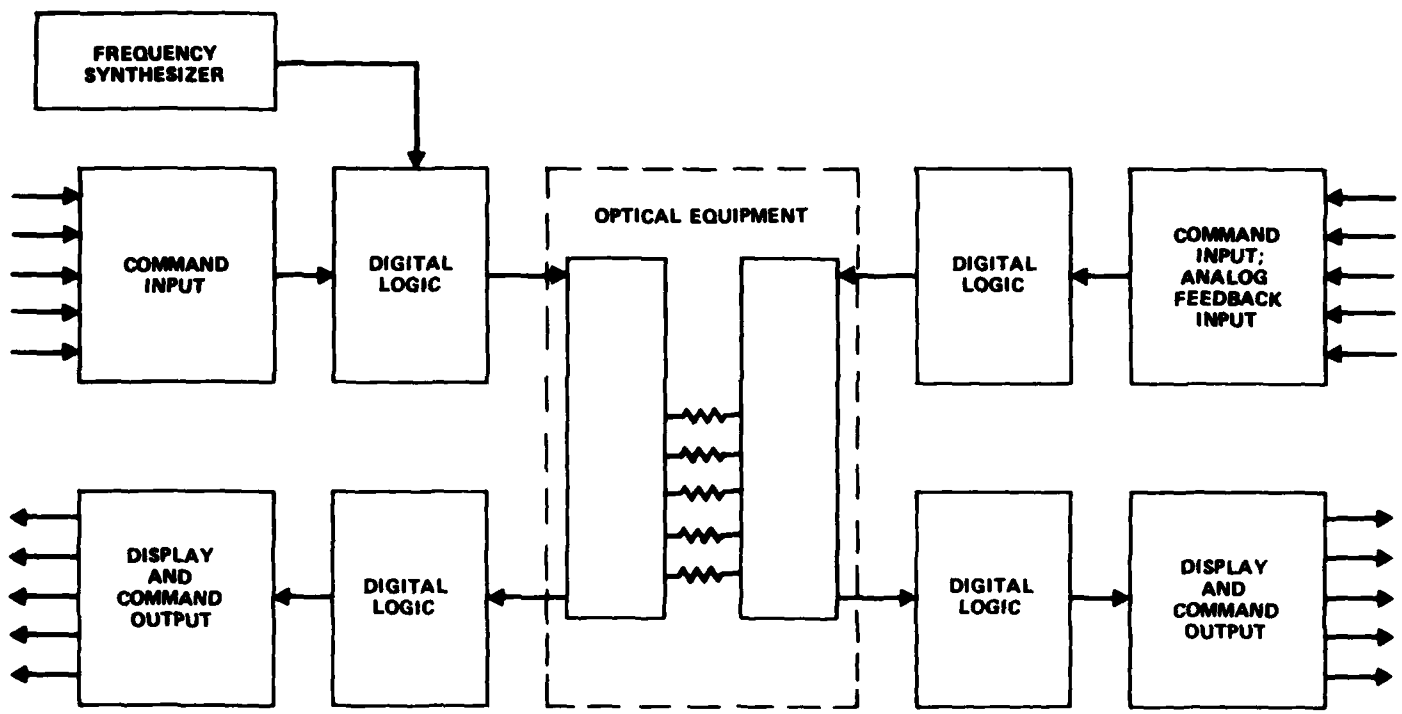


Figure 15 - Functional Diagram of Data Link
(See Reference 15.)

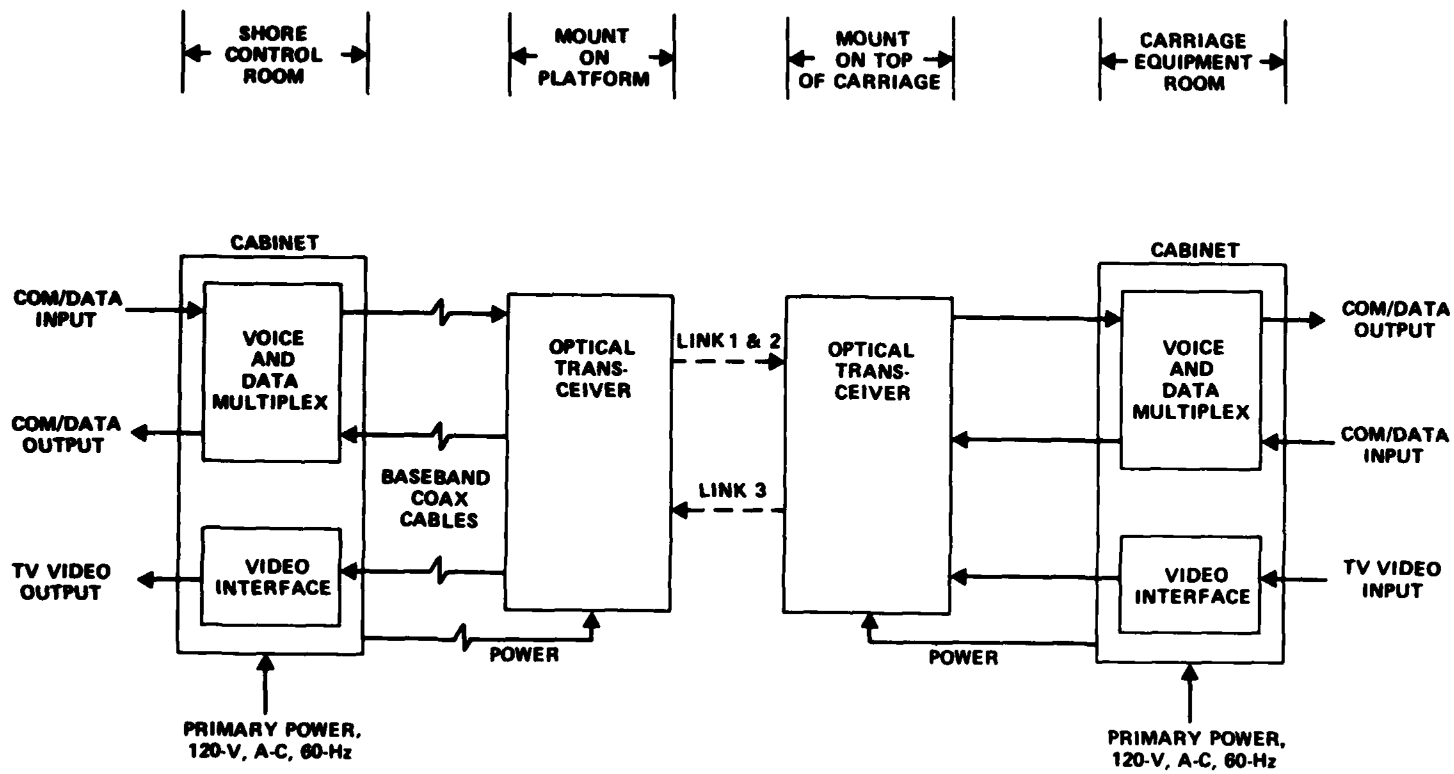
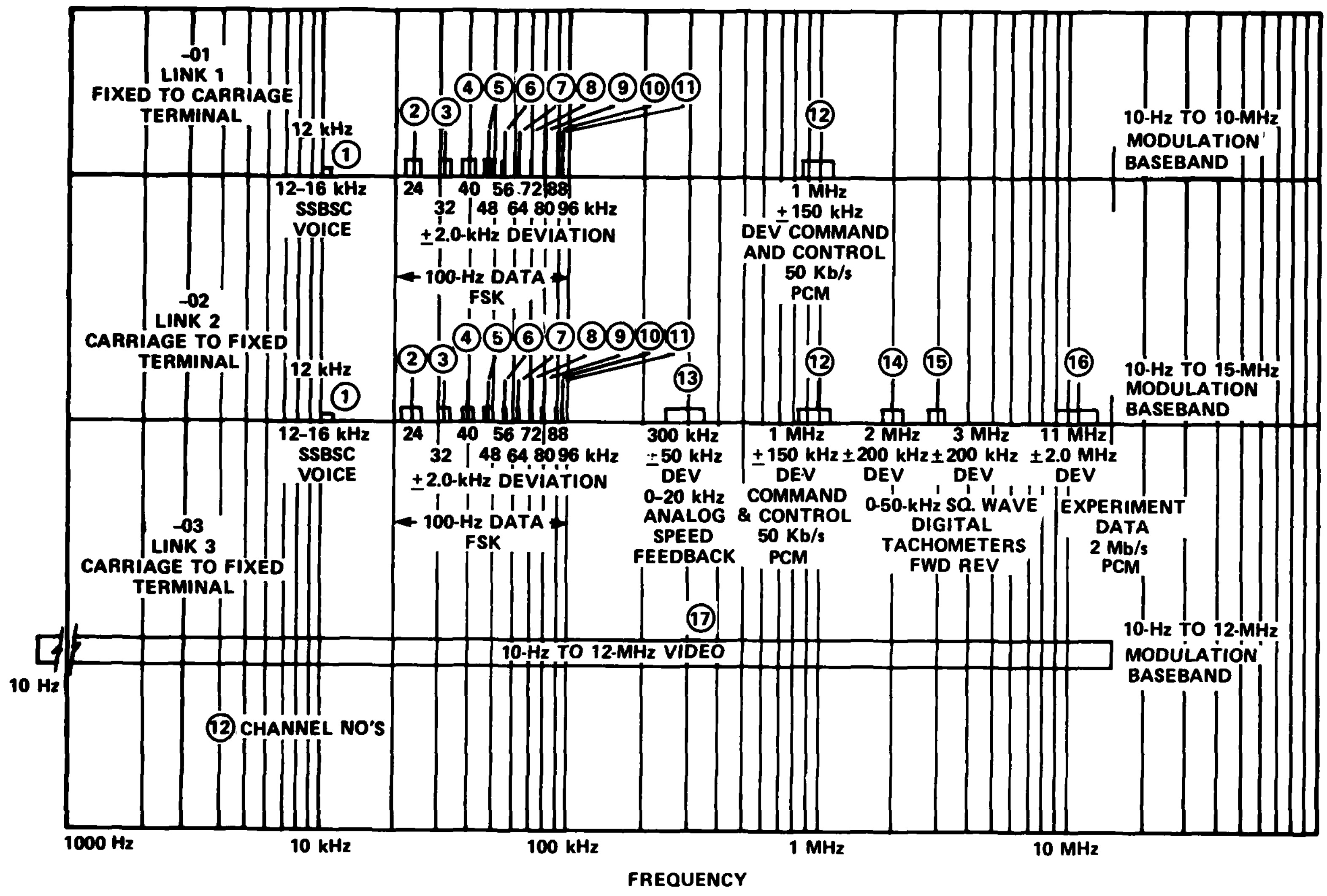


Figure 16 - Block Diagram of Data Transmission System



NOTE: SSBSC IS SINGLE SIDE BAND SUPPRESSED CARRIER; FSK IS FREQUENCY SHIFT KEYING; Kb/s IS KILOBITS PER SECOND; Mb/s IS MEGABITS PER SECOND.

Figure 17 - Data Link Modulation Plan
(See Reference 16.)

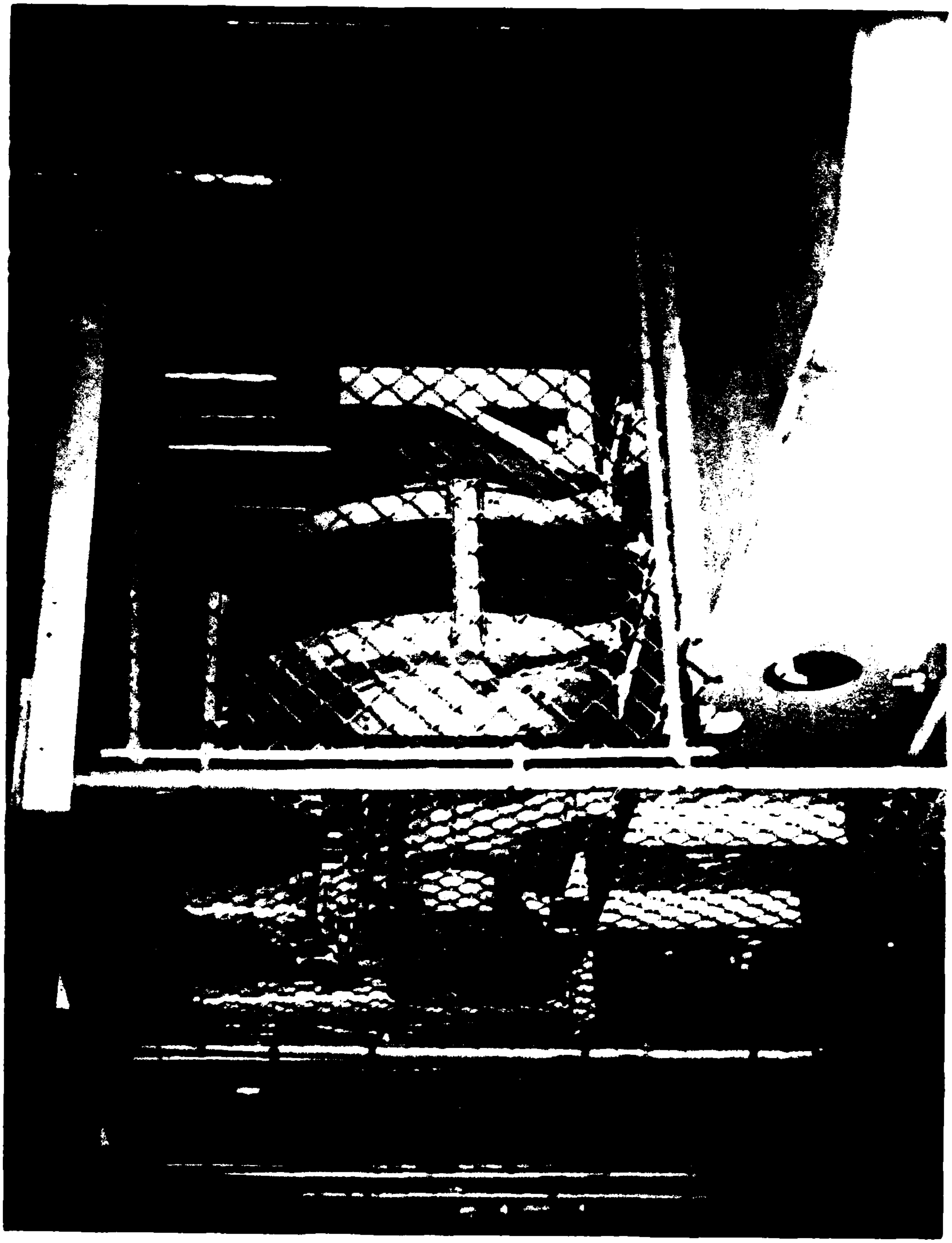


Figure 18 - Emergency Brake Equipment

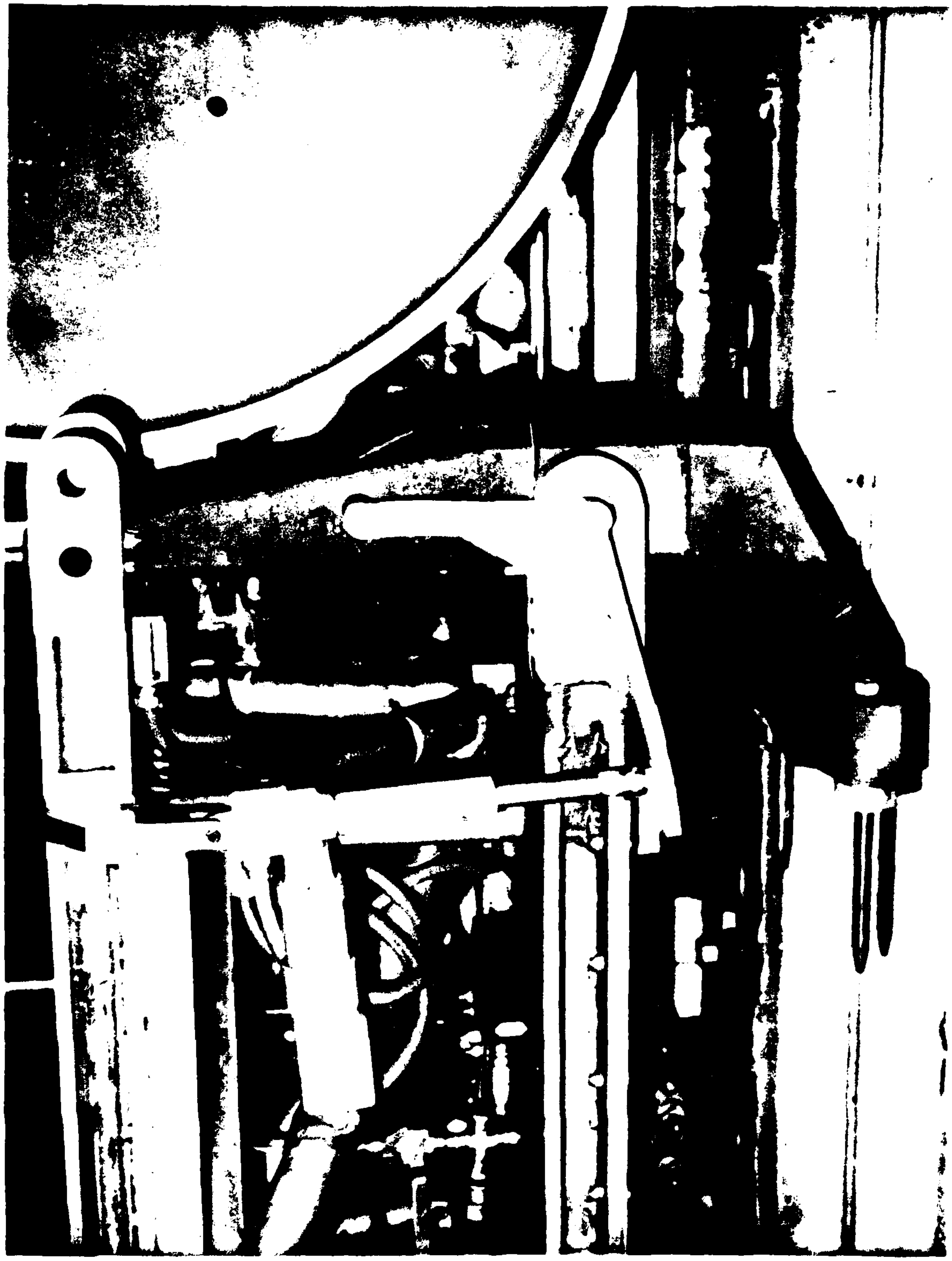


Figure 19 - Emergency Brake Arm on Carriage

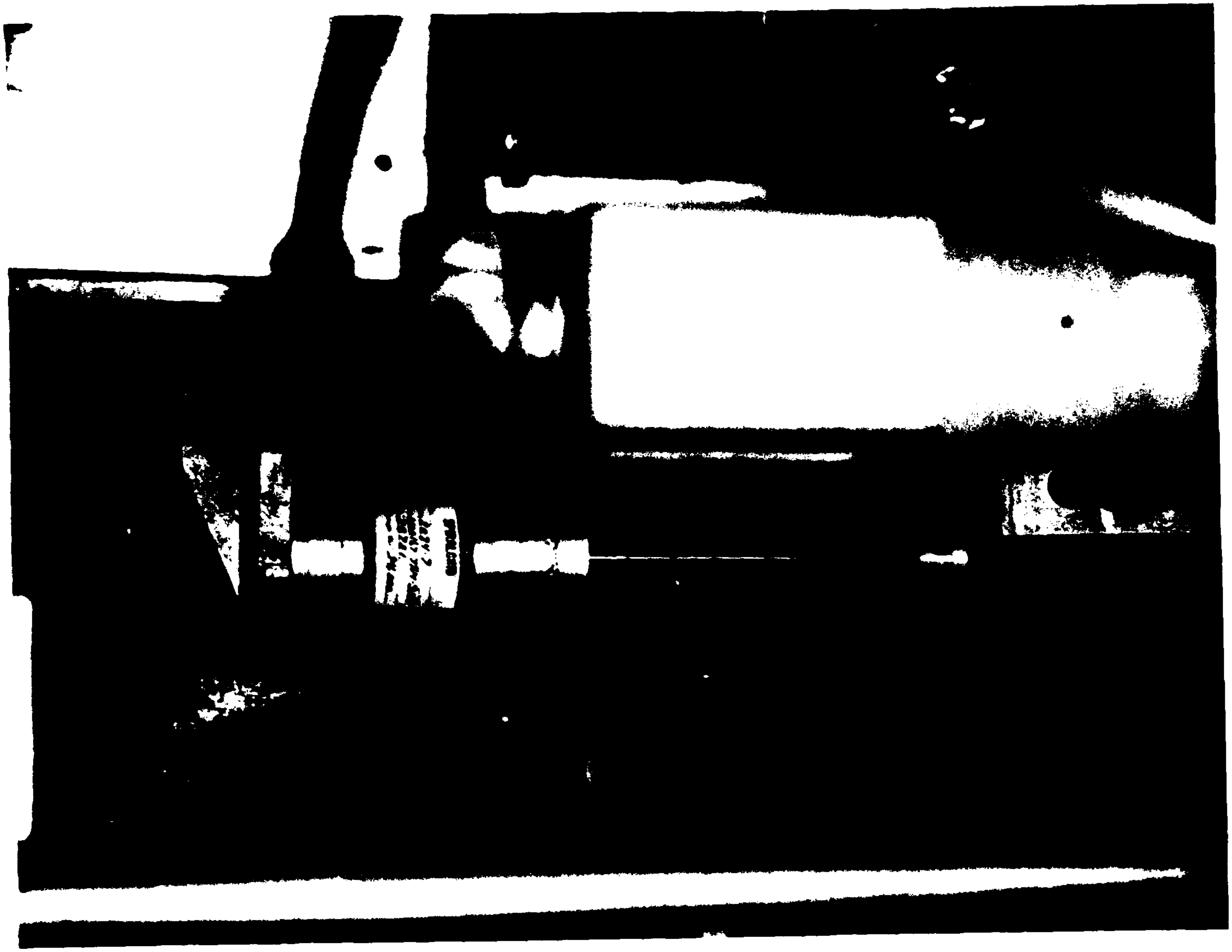


Figure 20 - Brake Arm Starting Engagement in Tape-Connector Assembly

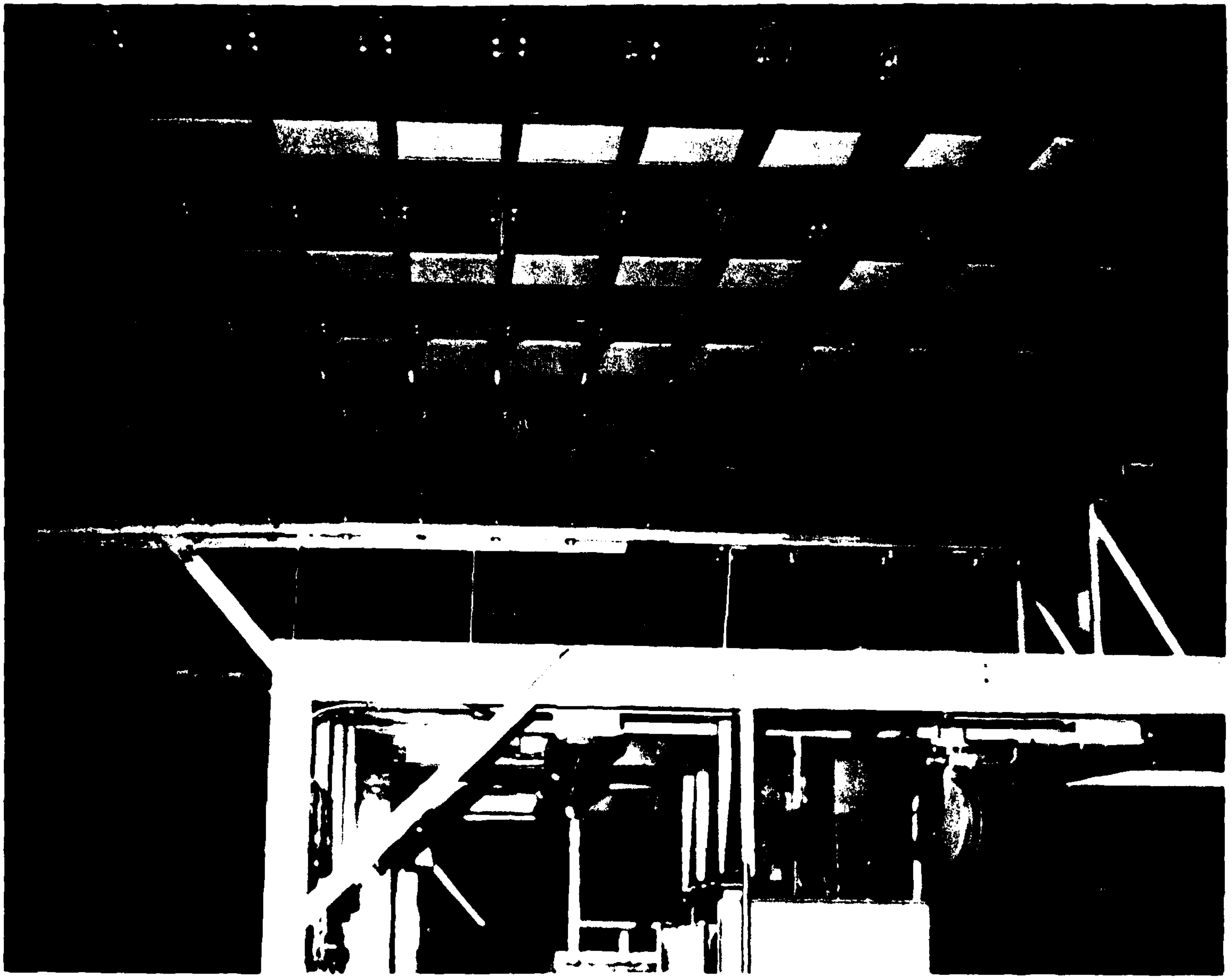


Figure 21 - Wall 4 Busbars and Collectors on Top of Carriage 6
Equipment Room

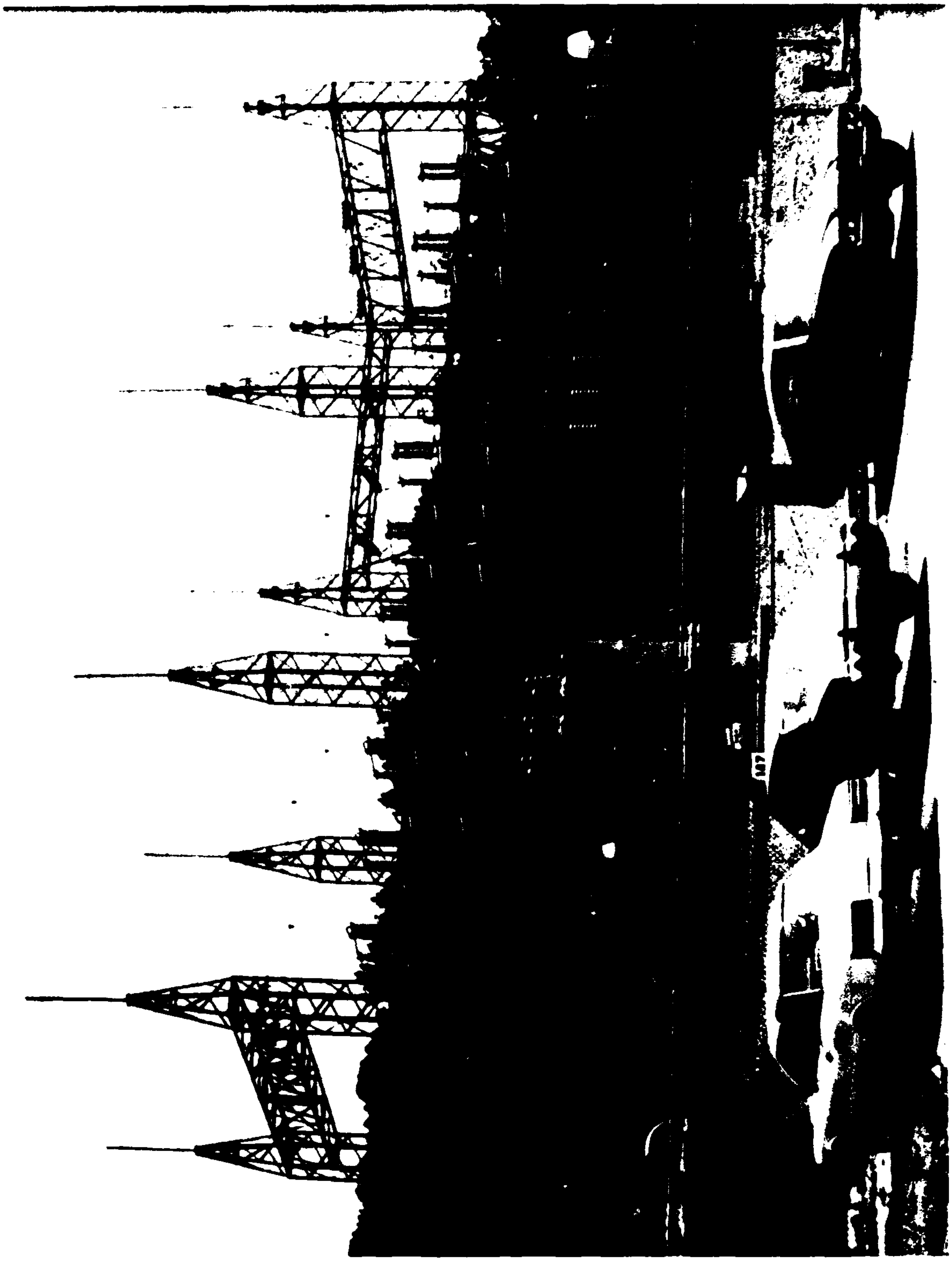


Figure 22 - Outdoor Substation

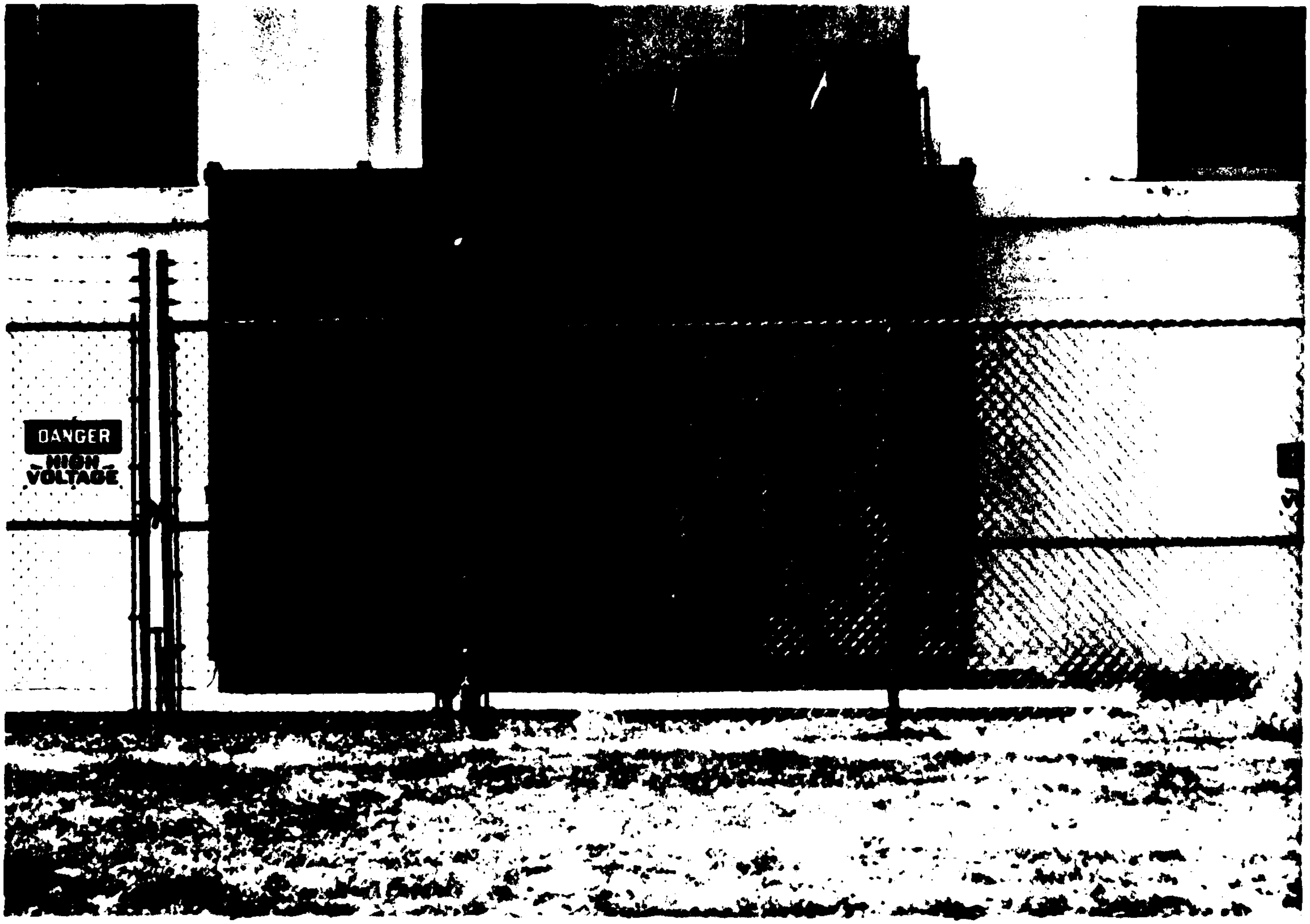


Figure 23 - Outdoor Switchgear

REFERENCES

1. Brownell, W.F., "Functional Specifications of a High-Speed Hydromechanics Tow Facility for the Naval Ship Research and Development Center," DTNSRDC Open File 11150 (Jul 1971).

2. AAI Corporation, "Study for a High Speed Tow Facility at Naval Ship R&D Center," Contract N62477-72-C-0042 (Aug 1974).

3. Chesapeake Division, Naval Facilities Engineering Command, "A&E Services for a High Speed Tow Facility at the Naval Ship R&D Center," Contract N62477-72-C-1337 (22 Sep 1972).

4. _____. "High Speed Tow Facility, Linear Induction Motor, NSRDC," Contract N62477-73-C-0127 (29 May 1973).

5. _____. "High Speed Tow Facility, High Speed Carriage, NSRDC," Contract N62477-73-C-0126 (1 Oct 1973).

6. _____. "Power Conditioner for High Speed Tow Facility," Contract N62477-73-C-0128 (29 Jun 1974).

7. _____. "High Speed Tow Facility Reaction Rail," Contract N62477-73-C-0130 (19 Jul 1974).

8. _____. "Frequency Brake Equipment for High Speed Tow Facility, NSRDC," Contract N62477-73-C-0135 (22 Jul 1974).

9. _____. "Speed Control System for High Speed Tow Facility, NSRDC," Contract N62477-73-C-0136 (22 Jul 1974).

10. _____. "High Speed Tow Facility, Substation and Distribution Equipment, NSRDC," Contract N62477-73-C-0129 (2 Aug 1974).

11. _____. "High Speed Tow Facility, Data Transmission Equipment NSRDC," Contract N62477-73-C-0134 (2 Aug 1974).

12. _____. "High Speed Tow Facility, Power Bus Bars, NSRDC," Contract N62477-73-C-0131 (19 Sep 1974).

13. _____. "High Speed Tow Facility Installation and Modification, NSRDC," Contract N62477-73-C-0137 (12 Sep 1975).

14. ABA, Inc., "Operation and Maintenance High Speed Carriage Speed Control System--Volume 1," Technical Manual, Contract N62477-73-C-0136 (1 Jul 1976) Figures 1-7.

15. _____. "Operation and Maintenance High Speed Carriage Speed Control System--Volume 1," Technical Manual, Contract N62477-73-C-0136 (1 Jul 1976) Figures 1-8.

16. Cosmos Engineers, Inc., "Operation and Maintenance Manual for Optical Data Transmission System--High Speed Tow Facility," Contract N62477-73-C-0134 (30 Aug 1976) Figure 3.

INITIAL DISTRIBUTION

Copies	
2	CHONR
1	DDR&E/Info. Off., Lib Br
2	CHNAVMAT 1 ADCNM, Lab Management 08L 1 Lab Resources Div, MAT 08L2
2	NAVFAC/Chesapeake Division
12	DTIC

CENTER DISTRIBUTION

Copies	Code	Name
1	15	
50	1503	
1	152	
1	154	
1	156	
10	5211.1	Reports Distribution
1	521.2	M.A. MacDonald
1	522.1	Unclass Lib (C)
1	522.2	Unclass Lib (A)

DA
FILM